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WATER WASTE CONTROL[1]

D. W. French:[2] The subject of water waste control seems to divide itself almost automatically into at least two separate parts, first, that having to do with wastage from service or house supply mains, including interior fixtures, and second, that concerned with the wastage from transmission and distribution mains.

For the reason that the speaker's personal experience has been in connection with an almost entirely metered system, leaking fixtures which are often neglected and the wastage that occurs if water is permitted to run to prevent freezing, result in added revenue in his case. If a water department can conveniently supply this additional demand which, in part, is only temporary, it may be regarded as legitimate consumption. Some wastage is constantly developing on services between the street main and meter, but on the Hackensack system, such wastage is located when examinations are being made of the transmission or distribution mains.

For a number of years the Hackensack Company has been systematically conducting water waste investigations, possibly to a somewhat greater extent than some companies or water departments. For illustration, reference may be made to what is done in one district, which, insofar as examinations are concerned, is typical of all others. This is the Weehawken high-service district which begins at the north boundary line of Jersey City and extends north to a short distance north of the line dividing Hudson and Bergen Counties, including seven municipalities. Located within this area are 116 miles of pipe in sizes from 4 to 30 inches, and about 16,300 house connections, serving a population of about 95,000, 100 per cent metered. The consumption in this particular district is about 11,000,000 gallons per day, with a per capita consumption of about 85 gallons. The company thinks 85 gallons is reasonably low in a district which includes a large number of manufacturing industries, one of which alone consumes 2,500,000 gallons per day.

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[1] Informal discussion by the New York Section on February 18, 1920. Further discussion is desired and should be sent to the Editor.

[2] Superintendent Hackensack Water Company, Weekawken, N. J.

About twenty years ago, when the Hackensack system was very much smaller than it now is, and when the daily output was about 10,000,000 gallons, we were accounting for 55 to 58 per cent of all water pumped, but up to that time had never reached 60 per cent. For the last several years, the company has experienced an exceedingly rapid growth and demand for water service, so that its daily output at the present time is only slightly less than 40,000,000 gallons. In spite of this growth, the percentage of water accounted for has been steadily improving, having been above 70 per cent for several years and for the year ending December 31, 1918, it reached 74 per cent.

The improvement in the percentage of water accounted for dates back several years and to a time when a small force of men under a foreman was organized and instructed in the use of the waterphone, to detect and locate underground leakage. The little organization consists of seven men, including the foreman, and each man is equipped with an aquaphone and a steel sounding rod. The brightest grade of laborers are selected for the work and their wages do not exceed $4.50 per day.

Water is supplied to the Weehawken high-service district by vertical triple-expansion crank and fly-wheel pumps, with single-acting outside-packed plungers, so that with a reasonable allowance for slippage and considering the gain or loss in the distributing reservoir, it is possible to obtain a good idea of the daily consumption in this district every morning by about ten o'clock. If there is no suspicion that the consumption is excessive and the pumps are running at a rate that just about maintains a certain level in the reservoir, it is assumed that there is nothing unusual taking place. But if, on the other hand, the reservoir gauge shows a loss of, say, 500,000 gallons in 24 hours, and it continues for two or three days without correcting itself, then these waste-detecting men go through this district making soundings on every fire hydrant on every street and avenue through the entire district. If the hydrant spacing is too great, then intermediate soundings are made from curb cocks located on service mains.

Practically all district investigations require some night work, for in thickly built up business sections there is often so much noise from trucking that it is difficult to get satisfactory soundings except at night.

When soundings are taken from curb cocks, it frequently becomes necessary to turn off the cock for a fraction of a moment, in order that the inspector may not be deceived by sound caused by the use of water through the service to which the cock is attached.

In making this inspection the men usually begin at the south end of the district, working north. It takes a week, using the full organization, on the average, to cover the district, although it is always possible, and frequently happens, that the trouble sought is located within the first day or two. In any event, if the district is covered entirely, or only in part, it is practically certain that the inspectors will pick up and locate everything in the way of leakage that amounts to much of anything. A man experienced in the use of a waterphone will detect sounds between 200 and 300 feet away in any direction and do it every time. Such being the case, the speaker feels justified in saying that there remains no good reason why underground leakage cannot be detected, located and stopped if continually followed up.

It has been observed frequently that a bad leak is readily traced by sounding along on the pavement directly over the pipe line, although the sound does not carry so far nor is it quite so distinct as a metal-to-metal sounding.

It is interesting to note the various kinds of sounds that accompany the various classes of leaks, or leaks that are on parts of the system where the pressure is greater than in some others.

A bad leak or broken pipe on a low-pressure main where water is escaping in a considerable quantity, possibly into a sewer or catch-basin under a low pressure and moderate velocity, but making no surface display, is hard to pick up, as it produces very little sound, at best a low rumble. Such leaks have often been located by lifting sewer manhole covers and noting if a larger volume of water is flowing in the sewer at any particular point than at several other points some distance away.

A broken main of, say, 6 or 8 inches, produces such a vibrating or rattling sound that the inspector is never deceived and, as a matter of fact, it can usually be detected at the surface and frequently without the use of the waterphone. Small leaks from service mains, if under a pressure of from 50 to 100 pounds, are usually accompanied by a sharp singing sound, and while they are of less importance so far as volume of escaping water is concerned, they are easy for the experienced man to pick up.

The reports by the inspectors making these examinations seldom read, "we think there is a leak at such a place" or "we think there is a broken pipe on a certain street," giving name and number, but they read, "there is a leak on a certain street," giving location, or "there is a broken main opposite a certain number," giving name of the street. The experience and training of these men has enabled them to reach accurate and definite conclusions, and when the pipe is exposed, their reports are found almost invariably correct.

The Weehawken high-service district represents about 19 per cent of the company's entire pipe system, and about 25 per cent of the total population supplied.

After the work in one district is completed, the men move on to another district and continue this practice until all the districts have been covered. Then the circuit is repeated. The men engaged on this work do practically nothing else; their whole time being spent making investigations for underground leakage, and there is no investment ever made by the company which yields a more satisfactory return.

The largest item of capital investment in most water works plants is necessarily in its transmission mains and distribution system, all of which are completely out of sight. There is no part of a water works plant which, once installed, receives so little attention as does its pipe system. After keeping in almost daily touch with this work on the Hackensack system for many years, the speaker is convinced that it is both possible and practicable for any water department or water company to examine and look after its pipe system carefully at regular intervals by a small trained and inexpensive organization such as has been described.

It is a waste of time, effort and money to send a few men over a pipe system who are not familiar with this class of work, and, having completed the survey, to consider the work finished. It is true that the experience thus acquired is an advantage both to the inspector and the department, but if the same men went over the same part of the pipe system a second time, they would pick up many leaks which, because of their earlier inexperience, were passed by on the first trip around.

In a large pipe system, leaks are so constantly taking place that it is impossible to take the position that we have no underground leakage. There is no way that will enable us to make any careful determination of what is taking place, except frequent examinations and constantly and faithfully keeping after the waste. The price we pay for reasonably good efficiency in our pipe system, or the price we pay for a high percentage of water accounted for, is measured by our everlasting vigilance.

A. W. Cuddeback.[3]—The price we must pay for elimination of waste is eternal vigilance. This applies particularly to the water system where the number of meters is small, but it also applies in a lesser degree to the community that is largely metered.

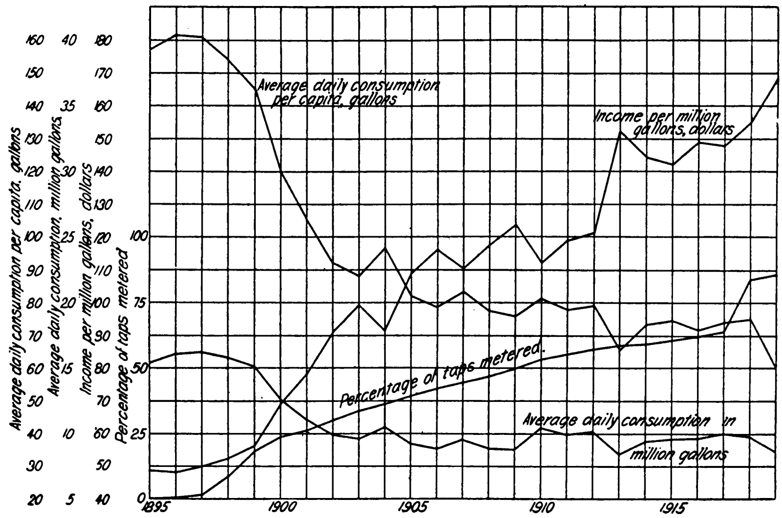

Fig. 1. Consumption, Income and Meterage Records of the Passaic Water Company

In illustrating what can be done in the way of controlling waste, the speaker has exhibited, on several occasions, curves pertaining to The Passaic Water Co. of Paterson, New Jersey, which are reproduced in figure 1, and has added a new curve to this collection, showing the rate at which metering has been carried on. The new curve shows the percentage of taps metered each year.

In the early years, when the reduction in consumption was greatest, from 1897 to 1903, the metering was most effective because all of the large manufacturing uses of water were metered within this period. Prior to 1897, there was no limitation whatever upon the quantity that manufacturers might use or waste, as the amount they paid was not affected in any way by the amount of water they used. Metering did not accomplish all of the results shown on the diagram, for in addition to the metering a large amount of inspection work was carried on through these years and those following.

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[3] Engineer and Superintendent, The Passaic Water Company, Paterson, N. J.

After 1903–1904, the metering was very uniform until 1918 and, with the inspection carried on in a lesser degree through that period, was effective in holding the consumption in million gallons per day, as against the increase in population.

Following the cold winter of 1917–1918, during which the consumption of water in northern New Jersey got beyond the capacities of the works available for supplying the communities, and created a very serious situation, The Passaic Water Company recognized that it had not been doing all it might have done to meet such a situation, in that it had not completely metered its supply, and decided to correct this omission. During 1918, about 4000 meters were set in the Paterson-Passaic district. This is shown as a percentage on the accompanying diagram. During 1919, the former percentage of increase in metering was continued. While these meters were set where it was believed they would do most good in checking the waste of water in cold weather, it does not necessarily follow that the results shown are entirely due to the additional meters put in service.

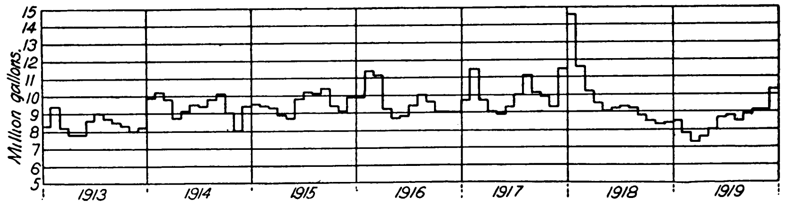

Fig. 2. Average Daily Consumption for Each Month, 1913–1919, at Paterson, N. J.

Figure 2, giving the consumption by months for a period of seven years, shows the particular effect of the extremely mild winter of 1918. There is another element still affecting the extremely low point reached during this period and, in fact, the low curve of almost the entire year, and that is the lessening consumption for industrial purposes due to industrial unrest and strikes. So there are three elements entering into the comparatively low consumption shown over the period covered by the last half of 1918 and the first half of 1919; additional metering, mild winter, and reduction in use of water for commercial purposes.

The present winter, 1919–1920, while not approaching the low temperature of 1917–1918, has probably been somewhat colder than the average winter, industrial conditions in this district have improved, and the consumption has reached normal conditions. The peak for the month of January is lower than the peak for any winter since 1915, and this can be fairly credited to the meters set during 1918.

Metering is the surest and most effective way of controlling water waste and conserving the supply, and it is becoming increasingly more important year by year to conserve our water supply. The time is approaching when near-by supplies will be exhausted unless particular attention is paid to the elimination of all possible waste in the use of water. Instead of water being free as air, the cost of it as delivered to the consumer is becoming greater and greater, and in order to avoid a very greatly increased cost due to going far afield for our supply, we should pay more attention to the conservation of what we have in order that it may serve the communities for longer periods.

Not being 100 per cent metered The Passaic Water Company is unable to make such a comparison as Mr. French has made, between the water served through the domestic meters and the total quantity, except in one municipality, Montclair. The company has not as yet made as good a record in that one small community as Mr. French has in his whole system. About twelve years ago the accounted-for water there was only 45 per cent, with 100 per cent of the services metered. This was largely due to neglect of the meters for several years, and neglect in following up any systematic inspection of mains or services. Following the checking up of this matter, the accounted-for water has been increased to about 68 per cent. That included two main features of the saving; one was bringing up the meters to a higher state of efficiency, evidenced by an increase in per capita revenue of about 50 cents, during a period of four years, and the other method was somewhat similar to that Mr. French described, using water phones pretty consistently. It has been possible to discover and correct many leaks in that way.

The per capita consumption in Paterson for 1919 was about 61 gallons, not including about 6,000,000 gallons of unfiltered water furnished for industrial purposes. This is a manufacturing town where there is a considerable quantity of water used for manufacturing purposes, so the company feels that it has fairly met the situation in that particular community. It is quite important, and probably Mr. French, being 100 per cent metered, will agree, to pay very close attention to all of the service meters, particularly those larger than 1 inch in size. Every meter that The Passaic Water Company has in service 2 inches and above in size is tested twice a year, and every house meter is removed for test at least once in four or five years. The company is taking out for inspection and test nearly 10 per cent of all of its meters each year. This has not only the effect of checking waste through water passing the meters unrecorded, but it also has another very good effect, keeping up the revenue for metered water.

W. W. BRUSH:[4] New York City's water waste control record shows very irregular application of the various methods of reducing waste. Probably all are fairly familiar with the objection that has always been made by the New York City real estate owners whenever any question of general metering has been brought before the Board of Aldermen, which, under the Charter, has control of the determination as to whether meters shall or shall not be placed on other than those premises where water is used for business purposes. It is now about three years since the last effort was made to extend the installation of meters by the department recommending that meters be required on the high-class apartment houses, where passenger elevators were in use, which represent some 2500 buildings. Public hearings on this subject were held at various places throughout the different boroughs by the Board of Aldermen, and those water works men who had an opportunity to attend such meetings felt that it was quite incumbent upon them to keep very much in the background, because the feeling expressed by those taxpayers who attended the meeting was extremely warm. Had they been given the sentence which in the opinion of the taxpayers they deserved, they would be now doing time in prison. The aldermen finally decided that water should be as free as air, and that the meters should not be placed on even this limited class of apartment houses. Water is not as free as air, and not quite as plentiful as hot air in New York City, and it has been in the past necessary from time to time to conserve the supply.

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[4] Deputy Chief Engineer, Bureau of Water Supply, Department of Water Supply, Gas and Electricity, New York.

At present the consumption at times has reached 750,000,000 gallons daily. During January it averaged 718,000,000 gallons daily, as compared with 650,000,000 gallons daily for January, 1918, which stands forth in the memory of all as being the coldest period ever experienced. This present high consumption is due to the continued cold weather during this winter, although there have not been the extremely low temperatures recorded that were experienced for a few days in 1917–1918. The present consumption is the maximum that New York has ever experienced.

There is hardly time to go over the history of the water waste control in New York, since an effort was first made about fifteen years ago to reduce the waste. In using the term "first made about fifteen years ago," the speaker is disregarding the efforts that were made very successfully some thirty years ago, when the Croton system was inadequate to meet the demands, before the new Croton Aqueduct was put into commission. Broadly speaking, the efforts to control waste may be grouped under four headings:

1. The reduction in pressure through the night hours or throughout the 24 hours, by manipulating the gates that control the flow into the various sections of the distribution system.
2. An appeal to the public by notices in the public press and by circulars to reduce the consumption of water on account of lack or threatened lack of supply.
3. House to house inspection to locate and stop leaks from fixtures.
4. Survey of the underground distribution system to determine leaks outside of buildings.

The reduction in pressure during the night hours has been carried on for many years in New York, and first started in 1905 in Brooklyn when the consumption was about 120,000,000 gallons daily, and there was a reduction of 5,000,000 gallons daily effected by dropping the night pressures some 10 pounds. This was done without any trouble from the viewpoint of the consumer.

The pressure is controlled in lower Manhattan since Catskill pressure has been used below 14th Street. The amount saved has been variable in quantity because a number of open connections have been found between the intermediate service below 14th

Street and the low Croton service, and at one time upwards of 20,000,000 gallons daily were being discharged unnecessarily at night in this district.

The public appeal has comparatively little effect, unless it can be pointed out that there is a likelihood of shortage of water unless waste is curtailed. It was possible to make a reduction of some 20,000,000 gallons daily in 1911 through public appeal, when there was a threatened shortage of the supply from the Croton system in the boroughs of Manhattan and the Bronx, and there was a somewhat similar experience in Brooklyn in the past, but an appeal to New Yorkers to save water on account of expense does not get very much return in reduction in consumption.

The question of reducing the loss outside of buildings, through a survey of the distribution system, is one which will be discussed by other New York engineers who have given that part of the work their special attention for a number of years past.

House to house inspection has always given excellent results financially in any of the boroughs where it has been undertaken. In Brooklyn, in 1912–1913, when it was carried on for almost a year, about $40,000 was spent for the inspection and reduced the maintenance charges between $300,000 and $400,000 a year. The reason for such excellent financial returns was that the city was then purchasing water from a private water company, and by cutting off that supply some $200,000 a year were thereby saved. The city was also able to shut down six expensive small pumping stations. At that time it was estimated that the effect of a house to house inspection would entirely disappear in about two years from the time it was made, the amount of leakage stopped reducing gradually as the time lengthened, and that conclusion has been upheld by subsequent experience.

House to house inspection in Manhattan was carried on in 1911 and, as a result of the press appeals, of the house to house inspection and of a survey for underground leakage, there was a reduction of between 60,000,000 and 70,000,000 gallons daily. The consumption for Manhattan and the Bronx before the campaign was started was 330,000,000 gallons daily. In Brooklyn, from 1914 until the Catskill supply was introduced early in 1917, there were usually about twenty inspectors engaged on water waste work, but it is difficult to determine how much the daily consumption was reduced thereby. The rapid increase in consumption in 1918 led to the inspection of all unmetered buildings in Manhattan between July 1 and October 31, 1918. About 150,000 leaks were found, and it is estimated that the consumption was then reduced by 26,000,000 gallons daily as a result of this inspection. The inspection cost practically nothing, because the department was then under war conditions and compelled to use its regularly employed force of inspectors, and there was almost no additional expense. It was necessary to postpone some of the meter reading work and read the meters less frequently, and there was a slight expense due to delay in billing for metered water. The same force was utilized in Brooklyn at the beginning of 1919 and covered about two-thirds of Brooklyn, discovering some 70,000 leaks. Here a reduction of about 16,000,000 to 18,000,000 gallons daily was shown by this house to house inspection. Assuming the regular rate of pay for inspectors the resultant cost was about $4.50 per million gallons saved in Manhattan and a little over $6.00 in Brooklyn. This cost is based on the theory that the amount saved will gradually reduce and run out at the end of two years, a very fair basis of estimate. The following per capita consumption figures are given for each five years since 1895:

YEAR	MANHATTAN AND BRONX	BROOKLYN
	gallons per day	*gallons per day*
1895	100	75
1900	130	88
1905	134 (maximum)	91
1907	—	101 (maximum)
1910	120	97
1915	109	76
1918	123	90
1919	121	87

The reduction shown in 1919 is due in part to the very mild winter, but is more especially due to the water waste prevention work that was undertaken in Manhattan in the latter part of 1918, and in Brooklyn in the early part of 1919.

New York's consumption under the conditions which exist here can be almost anything within a reasonable range that the authorities decide to have it. If the authorities will authorize water waste prevention work, New York City's per capita consumption can certainly be reduced to 100 gallons. If on the other hand it is decided not to have water waste control, the upper limit is hard to fix, but may be 50 per cent above this figure. New York will have to consider in the very near future whether it does or does not wish to reduce waste, and in that way postpone the undertaking of an additional supply. We have not yet received the supply from the development of the Schoharie watershed in the Catskills, which, when completed, will represent the final development of the present Catskill scheme for additional supply, and will add some 250,000,000 gallons daily to the present safe supply, but unless present estimates are incorrect, it will only be about 1935 before New York City will need more than the safe supply that will be available from the entire system of water supply now constructed. It took twelve years from the time that the present Board of Water Supply was authorized before the Catskill water was made available, and it was fifteen years from the time that the investigation was made for an additional water supply by the Burr, Hering, Freeman Commission, before the additional supply was introduced to the city, so, therefore, in considering additional supply for New York one must allow at least twelve to fifteen years for investigation and construction. It is evident that we are approaching the time when some consideration must be given to the question of an additional increment of water for New York City that will be commensurate with its demands.

George C. Andrews:[5] Buffalo has long been noted as the horrible example as a waster of water. Two years ago the per capita consumption was 340 gallons per day, but after two years intensive work on a water waste survey this has been cut down to 260 gallons per capita per day. The water bureau is proud of that, but still thinks there is room for improvement.

The question of water waste seems to be most naturally a local question and dependent upon public opinion. If there is a large supply available, little attention is paid to the waste of water and the per capita consumption is high. On the other hand, should the supply be small and increasing it an expensive proposition all legitimate means of reducing waste are apt to be employed. Buffalo is fortunate in having an unlimited supply on account of its location at the head of Lake Erie and the cost of furnishing it is only that of pumping.

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[5] Water Commissioner, Buffalo, N. Y. See, also, his paper in Journal, September, 1919.

Four years ago the city had just completed a new pumping station with a capacity of 150,000,000 gallons per day, augmenting the old pumping station which has a capacity of 180,000,000 gallons per day, giving a total pumping capacity of 330,000,000 gallons per day. This large pumping capacity is urged strongly by various interests against any effort to control waste, and it was only on account of the increasing charges for fuel that the reduction of water waste received serious consideration. When waste reduction was taken up with the City Council some of its members were strongly in favor of universal metering. Now, as a practical water works man, the speaker believes that the best way to eliminate all waste is metering, provided meter rates are properly made. However, due to the war and consequent scarcity of materials and labor, universal metering was impracticable and would not, under the most favorable conditions, have given so quickly the results which were obtained by a pitometer survey.

Public opinion was so strongly against metering and the necessity for a quick reduction in pumpage so desirable that a pitometer survey of the entire city was made, with the result that inside of two years the maximum pumpage under similar conditions was reduced from 250,000,000 gallons to 200,000,000 gallons per day. The daily per capita consumption in 1919 was 260 gallons, against 339 gallons in 1917. Since July, 1919, there has been a further reduction by months, except during the extremely cold months of December, January and February of this year, as compared with a year ago. While the consumption in these months was considerably greater, it is still far below what it was two years ago. The lowest daily pumpage in the past fifteen years was 109,670,000 gallons, which occurred on November 23, 1919.

When the 260 gallons per capita consumption in Buffalo is compared with the lower per capita consumption of other cities, it should be considered also that this figure includes the entire industrial and commercial use of water, for the city has practically no industries that have their own private water supply. Buffalo is only 7.0 per cent metered, yet the metered consumers used 37.0 per cent of the water pumped last year, which gives a per capita consumption for industrial and commercial use close to 100 gallons per day. The balance of 169 gallons covers the legitimate household use; water used for street flushing; fire services; public fountains; drinking fountains; the amount lost by unavoidable pipe leakage and waste in homes. This amount is still excessive, but there are certain local conditions which account for a large per capita consumption. The speaker knows of no other city in the United States which has such wide and deep lots as has Buffalo. Practically fifty per cent of the consumers have sprinkling charges and a large amount of water is used in the summer months for sprinkling the lawns and gardens and the wetting down of the street in front of the homes. Buffalo has long been noted for the fine condition of its lawns and it is the Bureau's policy not to stint the use of water for this purpose.

There is also another peculiar reason for the high water use. At least twenty thousand houses in Buffalo are cottages and have no cellars. In most cases these have the old style anti-freezing closet placed in a separate building, or in a room which cannot be heated. This type of closet when in repair is supposed to be anti-freezing, but they get out of repair easily and then have a continual flow of water. Moreover, the people are apt to let them run continually in the winter time rather than take the chance of their freezing. Furthermore, up to a year ago, the Bureau of Water had no control over the installation of plumbing, this being handled by the Health Department, whose sole aim it was to see that houses were equipped with an adequate supply of water and proper drainage facilities. As a result, in many of the better class homes water pipes are placed in outside walls, so that in severe weather it is necessary to allow water to run to prevent freezing. By a recently enacted ordinance all plumbing must be approved, as to location, by the Bureau of Water. This will result in much better work in the future.

During the waste control work it was found that through neglect people left these old style closets running the year around, paying no attention at all to repairing them. Public opinion was such that it was almost impossible to enforce the ordinance of metering places where there was a wilful waste of water. To correct this condition, the charge on such toilets was increased to $10.00 a year, with the proviso that upon presentation of a suitable affidavit, followed by inspection, that the closet was in good shape, the charge would be reduced to $2.50 a year. As a result, it was found that out of 10,000 such closets about 6000 affidavits were presented and practically 90 per cent of these had been repaired and were found in good shape. An important result of this was a big reduction in pumpage during the spring, summer and fall months. The Bureau does not assume the people will prevent the flushing of these continually in the winter time, but under the present system the closets are certain to be in repair at least twice a year. In case no affidavit has been presented, the Bureau assumes that the owners are wilful wasters of water and such places, under our ordinance, must be metered and the installation of meters is now being made.

The result of all this work to educate the people as to the extent and cost of waste and to the necessity of its control has been such that the Bureau now has public support back of its efforts, as the following illustration will show. Four years ago, when the proposition of universal metering was considered, it met with outside opposition and was turned down. On the other hand, three weeks ago, a resolution was presented to the Council authorizing the installation of 10,000 meters in homes, and it was passed without a dissenting vote and without criticism from the newspapers. These meters will be installed on the most wasteful services and a further reduction in waste of possibly seventy-five per cent should result. This is evident from the fact that a meter was installed on a wasteful consumer two years ago and the consumption for the first three months was at the average of $250 per year. A result of these large bills was that the owner soon put his plumbing in good shape, although no change in style of fixtures was made, and water is now being used on these premises at the rate of $40 per year. This service supplies one large house and two small cottages, having besides the sink fixtures three anti-freezing closets.

The question of the character of the per capita consumption is one that should receive consideration and the figures should be analyzed with reference to local conditions. A small city with a per capita consumption of 85 to 100 gallons may be fully as wasteful as Buffalo with its 260 gallons per capita consumption, as far as economical features are concerned, inasmuch as any increase in the per capita consumption may cost a large investment in new plant. Buffalo, however, is now equipped with intake, pumping capacity and distributing mains sufficient for 330,000,000 gallons per day. Its big saving is made when it gets the daily consumption within the capacity of one station and a further lowering in consumption saves only in the cost of pumping. The investment charges are the same whether 1,000,000 or 200,000,000 gallons are pumped.

Following the completion of the water waste survey by the Pitometer Company, the Bureau organized its own pitometer department, employing three engineers, five laborers and twenty inspectors. From original records, the Bureau knows the districts in which the waste is greatest and those where underground leaks are likely to be encountered. The engineers are constantly employed sub-dividing and measuring the consumption by blocks, and the inspectors are constantly checking up the house fixtures and services in the districts where the consumption is greatest. The system is to measure the block and then inspect for house waste, a record of the inspection on each house being kept. These records show the number of faucets leaking, toilets leaking, services leaking, and the number of people living in the house. Where fixtures or services are found leaking, a repair notice is served and a further inspection made two weeks later. If the repairs are not then made, water is shut off. After the block is put in good condition, another measurement is made by the pitometer, and if the consumption has not been reduced investigation is made for underground leaks in the mains. However, as the inspectors use the aquaphone on every service box, main leaks are usually discovered by them by the sound.

FRED B. NELSON:[6] In New York City, about one-quarter of the 390,000 services are metered, speaking in round figures; also about one-quarter of the total supply passes through meters. Thus about three-quarters of the 600-odd million gallons per day delivered to the city is unguarded as to waste, except for the special and limited efforts which the Department of Water Supply is able to make towards even a partial control. Also the situation leaves largely to conjecture the proportion of these unguarded millions that is wilfully wasted, or that is continuously running from defective or neglected plumbing, or from underground leaks in the maze of some three thousand miles of mains and connecting service pipes.

The question of universal or more complete metering of the city to control all over-ground waste has been frequently agitated and as frequently rejected as a proposition too distasteful to be approved by a public accustomed to water "as free as air" or purchased on a basis almost as business-like as that used by the old Romans, who charged for the water in proportion to the size of the service pipe.

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[6] Engineer-in-Charge Water Measurement and Water Waste, Department of Water Supply, Gas and Electricity, New York, N. Y.

The possibilities for the development of underground leakage depend largely on sub-surface conditions. In the Boroughs of Brooklyn, Queens and Richmond, as a rule, the existence of underground leakage is revealed by visible surface indications. In Manhattan and The Bronx the reverse is true, and, excluding sudden or serious breaks, the chances of a leak showing at the surface are very remote. This is due to the almost universal rock and the very uneven original surface, necessitating extensive grading as the city developed, whereby large areas now consist of loose rock fill, while others that are cut to grade include sewer pipe and conduit trenches and subways back-filled with loose rock. This condition provides numerous and ample channels to conduct leakage to the sewer or to unexpected locations, often very distant from the source of the trouble. It is therefore principally in these two boroughs that the special underground waste detection work has been carried on. The force and the methods adopted have been developed in an endeavor to meet these conditions most effectively.

The difficulty of locating leaks in these boroughs is often materially increased, particularly in lower Manhattan, by the congestion of sub-surface structures, including gas mains, steam mains, high and low tension electrical conduits, as well as the frequent duplication in the same street of trunk and distribution water mains and the high-pressure fire system, all more or less rearranged by the construction of subway or other structures, which also tends to subject mains and services to unequal settlement.

Since 1911 a special force under engineering supervision has been assigned principally to the work of underground waste detection in these boroughs. To date, this force has located and repaired underground leakage totaling over 75,000,000 gallons per day, an amount equal to a supply for a city of 750,000. Probably 50,000,000 gallons of this, or the bulk of that located previous to 1918, represented leakage that was causing no apparent damage or complaint, and which could have continued indefinitely or until revealed by the caving in of undermined paving, settling and breaking of adjacent mains, or other damage. That long continuance of such leakage without damage or public inconvenience is possible is evidenced in a number of cases.

Several leaks of approximately 500,000 gallons a day have been found flowing to the sewer through a clear channel directly under rock-filled macadam streets, with no visible surface indications.

Numerous other cases have been found in which the evidence is quite conclusive that the leak had existed for years.

In one instance a supply of good clear water, utilized for about ten to twelve years for condensing in a hotel plant at 59th Street and Fifth Avenue, was cut off by the location and repair of two or three joint leaks in a 48-inch main in the avenue. These leaks were not serious for a main of that size, but the work was carried to a conclusion when it was discovered that the hotel meter bill increased by about $5 per day whenever that main was shut down.

A "fresh water spring" in a swamp near City Island Road, patronized several years for its superior quality of water, was discontinued by the location and repair of a leak of 1,400,000 gallons per day in an old broken 8-inch main paralleling a newer 20-inch.

In view of such and much other evidence, and as a basis of estimating the cost of waste detection work, it was thought conservative to assume that on an average the leaks found would otherwise have continued for two years, so that for each million gallons per day of underground waste stopped, 730,000,000 gallons would be assumed as saved. On this basis the cost of the work in 1911 and 1912 per million gallons saved was $6.32. This was reduced each succeeding year, by improvement in methods to more effectively meet the conditions, to $1.15 in 1917.

Since 1917 it has been found profitable and advisable to utilize this special force in relieving the repair shops of cases of leak location in which extensive street openings, traffic interference or damages could be avoided by the application of engineering methods, and the force has been increasingly utilized in this way until their waste detection work has come to be almost exclusively on complaint and emergency matters, and the systematic search for leaks has had to be abandoned.

This procedure eliminated the previous policy of systematic search in sections where the greatest saving of water could be secured at the least expenditure of time, and called quite frequently for an expense in time and labor out of all proportion to the value of the water saved. This, together with the increase in salaries and wages, has advanced the cost of the work per million gallons saved from the $1.15 in 1917 to $3.19 in 1919. It will be noted that all these costs are well within estimates of the present value of New York City water.

The emergency work is, of course, of prime importance and must not be neglected, though it is to be regretted that the systematic work effecting the greater saving of water had to be discontinued at a time when the general increase of pressures with the introduction of the Catskill supply has so materially increased consumption and, no doubt, the leakage. This increase of consumption and leakage is evidenced by the fact that the Catskill supply was seriously overdrawn before large and needy areas of Manhattan could be reached with the proposed extensions of services. However, with the congestion of sub-service pipe lines, electrical and steam conduits, subways and other structures serving to convey or deflect the flow from underground leaks, the emergency work, particularly in lower Manhattan, is not lacking in interest and variety, and the results have furnished the satisfaction that goes with the frequently expressed appreciation of the public and a growing demand for the service.

At the present time the list of matters for attention is far ahead of the ability of the present force to handle it, and, during 1919, this situation being realized, special funds were provided for increasing the waste detection force and equipment to meet the situation more adequately. This additional force and equipment could not be secured in time to be utilized effectively during that year, but it is hoped that it will be possible to get abreast of the emergency work during the present year and possibly resume some of the more aggressive systematic search for leakage.

The force for the past three or four years has consisted of an assistant engineer in charge and two field parties, each under the immediate direction of an assistant engineer, and each including one rodman, one calker, three laborers, an auto engineman, and the necessary equipment, including motor truck and Ford cars for the engineer. The increase of force provided for is such as to provide two additional field parties to be under the direction of the same two field engineers.

It has been stated that the portion of the unmetered supply wasted is largely a conjecture. Past records, however, of systematic underground waste detection work, which has included consumption gaugings, furnish some evidence. On two or three occasions such work in specific uptown areas having a consumption of from 8,000,000 to 15,000,000 gallons daily has resulted in the location and repair of underground leakage totaling 15 to 20 per cent of the supply, and of course it must be borne in mind that this by no means represented a clean sweep.

In such work numerous small leaks are overlooked and the time necessary for locating very small leaks is not intentionally carried to an uneconomical extent. From such experience it would naturally be concluded that a waste of at least 15 to 20 per cent is possible from underground leakage. Also, in these areas, largely residential, consumption gauging will show a minimum night rate equal to 50 per cent of the maximum rate for the day. In lower Manhattan in 1902 the minimum night consumption in the strictly business area south of Fulton Street was 54 per cent of that existing during business hours and 74 per cent of the average rate for the 24 hours. On account of the complexity and age of the system in this section, systematic work is much less economical than in the uptown areas and little has therefore been done. In the necessary rectifying of complaints, however, frequently one to one-half dozen leaks are located and repaired, which are causing no inconvenience or damage aside from a continuous waste of water, before the one responsible for the trouble is stopped.

The leaks located and repaired in general average 50,000 to 75,000 gallons per day, but in case of complaint it frequently becomes necessary to spend a large amount of time on leaks of but a few gallons a day, when all ordinary methods fail, and in rare cases the primitive method of digging is the only recourse.

Another class of leaks which are extremely difficult to locate are abandoned service pipes, which frequently are closed by bending over and hammering the end of the pipe within the property lines to avoid the expense of street excavation necessary to shut them off properly at the main. Here again all ordinary methods of waste detection fail, due to the fact that on account of the usual length of service pipe little or no sound is produced which can be detected by aquaphones. In one instance in last year's work the practical stripping of a 6-inch main became necessary and twenty-five street openings were made, the work terminating in the location of an abandoned service pipe discharging about 50,000 gallons per day. This flow was making its way underground in a northwesterly direction beneath cellars and areaways and appearing at the point of complaint in the next block. In this case the size of the leak was sufficient to have been easily located by the ordinary methods if it had occurred nearer the street main, but on account of the length of service pipe with, undoubtedly, practically full opening at the end no noise was traceable by ordinary soundings.

In other cases of abandoned service pipes it frequently becomes necessary to make deep soundings without regard to the location of the main until the location of the highest elevation of the water in the ground is determined. An excavation at this point usually uncovers the leaking portion of the service pipe, after which its connection to the main is located by means of a wireless pipe locator.

The record of the work done in 1919 may be of interest as illustrating the frequency of the different classes of leaks. The leaks stopped totaled 9,348,000 gallons per day. The average size of the leaks located was 54,000 gallons per day. The different classes were as follows:

	NUMBER	PER CENT
Live service	87	50
Abandoned service	17	10
Blown joints	63	36
Leaking valves	5	3
Cracked pipe	1	1
Total number of leaks	173	100
Openings per leak (excluding the above mentioned one requiring 25 openings)		1.2
(Including the one with 25 openings)		1.32

As regards the comparative utility of the aquaphone and the pitometer on underground waste work, Mr. French has explained how under the conditions obtaining in his system the aquaphone is used almost exclusively in locating the underground leaks, the reason there being, as he explained, that he has convenient and accurate methods for continuous gauging of the consumption in the various districts, which are probably sufficiently small to immediately reveal any leakage of consequence that may develop. In New York City a different set of conditions exists, accounting for the extensive use of the aquaphone and the slight use of the pitometer.

The pitometer is primarily a convenient and accurate measuring device, and is so used on waste work for the detection of leakage only within shut-off limits, except in cases where the leakage is a sufficient proportion of the capacity of the main to enable simultaneous gaugings. The aquaphone, on the other hand, is, of course, worthless for the determination of quantities, but is primarily utilized for the final location of individual leaks.

In New York City, as already explained, the waste detection work has developed into that of emergency, to the exclusion of practically all systematic work. In other words, each emergency call satisfies the detection part of the problem, the location of the leak only remaining, when, of course, the aquaphone is the principal device to be used. Were it possible for the present force to undertake the survey of districts and systematic work, the pitometer would be by all means more extensively used, as by such means the Bureau of Water Supply would have a much better line on the results of its work. In New York City there are few if any means of continuous recording of the consumption in very small areas, and in systematic work the pitometer would be used for regular gaugings of district consumption.

On this work, as at present conducted with the use of the aquaphone, undoubtedly leaks of a certain character are missed which the pitometer methods would detect. One class is that of abandoned service pipes, which are extremely numerous in the congested and older portions of the city. These seldom, if ever, give any sound indications, and it is practically only those which have caused complaint that have been located.

The aquaphone, also, is of course out of the question in detecting excessive plumbing and fixture leakage within the premises, illicit use of water, and losses of other description which involve no sound indications, and are factors to be considered in other cities where the work involves more thorough and detailed investigations, and where accurate means of watching the consumption by small areas are lacking.

New York City has an equipment of pitometers and these are used for gauging the flow in trunk mains, temporary gauging of consumption in isolated districts, testing of pumping engines, etc.

H. T. HAVILL:[7] With the water works, as in every other business, in New York City, time is a controlling factor in many of the things to be done and therefore the methods adopted for locating leaks are those which will give the greatest return in information, for the amount of time expended. For this reason the old method of districting the distribution system and measuring the flow into each district, shut off during the early morning hours, has been supplanted by establishing a system of control gradients and aquaphone testing to accomplish the same end.

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[7] Assistant Engineer, Bureau of Water Supply, Department of Water Supply, Gas and Electricity, New York, N. Y.

The leaks most difficult to locate are those from abandoned service pipes which have been bent over and hammered up, and at some later date open up and start to flow. For instance, while aquaphoning in the vicinity of 65th Street and Fifth Avenue, a leak noise was heard on the line gate in 65th Street, and, on further investigation by means of driving a bar through the street pavement, over the water main, until the bar and pipe were in contact, then listening with an aquaphone on the bar for the vibration produced by the leak, until the leak noise becomes most distinct and there making an excavation, an abandoned tap was located which, when shut off, stopped the flow of water to a large residence. This leak had been running since the house was built some ten years and was supposed to have been a spring. The flow of water into the premises was about 100,000 gallons per day. To take care of this flow of water, the entire cellar was first water-proofed at a cost of $12,000. This failing to keep the water out, a sump was built and an electrically operated centrifugal pump and also a water siphon were installed. After stopping the leak, the monthly meter bills for water were reduced from $41.10 to $8.10, showing that the siphon consumed $33 worth of water per month, or $396 per year. This together with the electrical bill to run the turbine, the secretary to the owner stated, amounted to $500 per annum. Something of the magnitude of this leak can be appreciated from the fact that its existence for ten years cost the owner of this residence more than $17,000 and wasted 365,000,000 gallons of water.

Another very typical condition of waste, caused by an abandoned service, was exemplified in a leak the speaker was called upon to locate some time ago at the Russell Sage Foundation Building on the corner of 22nd Street and Lexington Avenue. The basement of the building was water-proofed to take care of the ground water, but when an old, abandoned service opened up and started to flow, causing a pressure under the basement floor, the tar which had been used in water-proofing, began to work up through the concrete and formed globules on the floor, which grew in size until the water within them burst the globule.

The abandoned service which caused this trouble was located by driving a bar through the pavement and into the ground until the point of the bar penetrated the sub-surface water level. Then, marking the bar at the street surface and withdrawing it, then measuring from the mark to the point where the water wet the bar, a point was determined on the gradient of the sub-surface water which, when followed up, led to the source of the flow, as the gradient will rise to a maximum at the source. This leak, so it is said, cost the owner of the building upwards of $3000 before the Bureau of Water Supply was called in to find the trouble.

In order not to give the mistaken idea that making the soundings before mentioned is a simple matter of driving a bar into the ground, it should be said that the maze of sub-surface structures, pipes, cables, ducts, etc., which permeate the sub-surface of the streets in New York City is so apt to be damaged by driving a bar through the pavement at random that the method of sounding requires some one to be in charge who is not only familiar with all of the underground conditions throughout the city but who has had sufficient experience in this particular line of work to interpret properly the condition indicated.

As a sample of what might happen if this work is carried on carelessly, a case may be cited. A plumber a short while ago, while digging in the street along the line of the Lenox Avenue Subway, in Harlem, accidentally struck a power cable with a pick and the man was not only nearly electrocuted but it cost the Interborough Railroad in the neighborhood of $75,000 to make the repairs.

Another case which shows what a danger the waste from abandoned services may become will become evident from experience with a $\frac{5}{8}$-inch tap found leaking in Columbus Avenue at 76th Street. There was no street indication of a dangerous sub-surface condition and the leak was located by the aquaphoning and sounding method before mentioned. When the first sounding was made and the bar had penetrated the concrete foundation of the street, the next blow with a hammer drove the bar through the pavement and out of sight. An excavation was made and it was found that the water had washed out sufficient earth to leave a hole large enough to put a good-sized truck in and had undermined a 30-inch gas main, which, together with the foundation of the street surface, was the only support given to street traffic over this section. It is probable that if this condition had continued to exist very long, heavy trucks would have fallen into the hole and the 30-inch gas main would have been broken, which might have caused an explosion entailing considerable damage.

William A. McCaffrey:[8] The question of water waste control, of vital importance to every water works man, is especially so where the water has to be pumped through an unmetered system. The superintendent or manager of such an unmetered plant is confronted by the proposition of furnishing water in unlimited quantities to wasteful services, irrespective of pumping facilities, which in the winter months particularly seriously affects the fire pressure, due to running faucets and toilets to prevent freezing. We all agree that the only way of preventing this waste is by universal metering, but, as Mr. Andrews stated, this is almost impossible in many cities, owing to different circumstances, and it is then the duty of the management to do the next best thing.

The speaker is not feeling so badly now as he did before this meeting as regards the leakage and waste in Oswego, since hearing from New York and Buffalo. At Oswego house to house inspections reveal may leaky fixtures, which, if not repaired in 10 days, are charged double rates; on failure to pay, the water is shut off. The department has been cutting down the drinking fountains, shutting off the schools over Saturday and Sunday, the schools being very wasteful, and doing everything possible to reduce the consumption.

With all the cutting down, the pumpage did not decrease to any appreciable degree. The city had been visited from time to time by E. D. Case and, finally, on one of these visits it was suggested that he make a survey of a section of the city to ascertain if there was any underground leakage. The offer was accepted and about November 1 the pitometer investigation was started. The operator first took a measurement of the pump for slippage and then took a 48-hour measurement of the section to be surveyed. Then he sub-divided the section into districts, and in one of the districts he located a leak of 120,000 gallons, blowing away under a State road into the river. In another district he located a leak of 138,000 gallons in a fire line which ran into a manufacturing plant. This line was under a concrete floor. After the owners were notified they stated that five years previous they started to dig a pit in their plant and the water came in on them so fast they closed it up, letting the water get away into the sewer. They thought that as the soil was springy, the water no doubt came from there.

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[8] Secretary and Superintendent, Water Department, Oswego, N. Y.

Another leak of 102,000 gallons was located in an 8-inch fire line which ran into a plant and was cross-connected with an auxiliary industrial supply and ran across the street to another factory, the valve between the two lines not being tight. Another leak of 70,000 gallons was discovered in a 6-inch fire line, the leak being under a water wheel, the water getting away in the river. In one month's time there were located and stopped leaks totaling about one half a million gallons of water in one locality. For quick returns therefore, the pitometer is the instrument.

F. T. KEMBLE:[9] There is one method of finding leaks which has not been touched on that is used at New Rochelle. There all services are metered. The day's consumption is measured by Venturi meters and the pump counters, both of which are checked from time to time by a pitometer. Whenever the pressure gauge charts have shown a lowering of pressure and the consumption has run too high, it has been found advantageous to send a man out with a list of hydrants on which he is to take the pressures. Any man who can attach a gauge and open a hydrant will do for this work. When the list of pressures is turned in, it is compared with the hydrant cards. When a drop in pressure is found, a man is sent to that spot to phone the hydrants, curb cocks or services, and get the repair gang on the job.

Great numbers of leaks are found where sewers have been laid. New lines or replacements not properly back-filled do not support the water main. Again, where drains have become broken or choked, the water in finding its way to the sewer often washes away the earth under the water pipe, causing it to settle. Most leaks are found where one end of the pipe rests on rock. Where the pressure is fairly maintained at one or two hydrants and much lower at an adjoining one, the break is close at hand, and if the inspector can find a rock outcrop along the road, he knows just where to phone. The break is generally there.

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[9] Secretary, New Rochelle Water Company, New Rochelle, N. Y.

DR. F. E. HALE:[10] When the notice of the meeting was sent out, it did not occur to the speaker that the Laboratory Division of New York City's Water Department had any connection with the water waste prevention. While listening to the papers, it has been suggested that there is a close connection between the laboratory work and water waste detection, the latter being closely connected with water waste prevention.

Some 300 or 400 samples of water a year are collected from cellars, conduits and excavations and sent to the laboratory for analysis. In many instances it is possible to tell whether or not the sample is from the city water, and in some instances to say whether it is Croton water or Catskill water. The waters are naturally divided into three main groups: city supply, sewage, and ground water or unclassified. The most important determinations are the physical character of the water, particularly odor, the microscopical examination, and the chemical analysis for free ammonia, albuminoid ammonia, nitrate, chlorine, hardness and alkalinity. Frequently it can be definitely said that the sample is sewage, and sometimes definitely that it is ground water. In many instances there are intermediate analyses which do not permit of a definite statement, since water in passing through the soil and concrete walls frequently becomes contaminated to such an extent that its character is utterly changed.

In those instances where the information is definite, it is very definite. For example, if there are microscopic organisms present in the water, it must be either city supply or sewage, no matter what the other determinations show. If it is sewage, there is additional definite information furnished by high figures for free and albuminoid ammonia, chlorine, and frequently an alkalinity which is higher than the hardness; nitrate would be low or absent; the odor is distinctive. Frequently samples upon shaking will produce foam due to the presence of soaps. True ground waters are usually high in nitrate, although the latter may sometimes be reduced to cause a high free ammonia. Such samples usually contain considerable chlorine and hardness and very little free and albuminoid ammonia.

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[10] Chief Chemist, Bureau of Water Supply, Department of Water Supply, Gas and Electricity, New York, N. Y.

The following table shows conclusions reached from the analyses of 362 samples submitted during the year 1919:

Cellar water samples, etc.

	NUMBER OF SAMPLES		PERCENTAGE	
City water*	70		19	
Probably city water	29		8	
Possibly city water	39	138	11	38
Sewage	36		10	
Probably sewage	7		2	
Possibly sewage	3		1	
House drainage	2			
Trade waste	1	49	1	14
Not city (unclassified)	35		10	
Probably not city (unclassified)	134		36	
Ground water	3		1	
Salt water	3	175	1	48
Total		362		100

* 3 Croton; 3 Catskill.

It is evident from the above that the Laboratory Division is of considerable assistance in indicating whether it is necessary to dig for a leak.